ELECTRICAL CONDUCTIVITY OF CARBONACEOUS CHONDRITES AND ELECTRIC HEATING OF METEORITE PARENT BODIES

Al Duba, Lawrence Livermore Laboratory, P.O. Box 880, Livermore, CA 94550

The electrical conductivity of samples of the Murchison and Allende carbonaceous chondrites is 4 to 6 orders of magnitude greater than rock forming minerals such as olivine up to 700 C. The remarkably high electrical conductivity of these meteorities is attributed to carbon at grain boundaries. Much of this carbon is produced by pyrolyzing hydrocarbons at temperatures in excess of 200 C. As temperature increases, light hydrocarbons are driven off and a carbon-rich residue or char migrates to the grain boundaries enhancing electrical conductivity.

Assuming that carbon was present at grain boundaries in material which comprised the meteorite parent bodies, we have calculated the electrical heating of such bodies as a function of body size and solar distance using the T-Tauri model of Sonett and colleagues (1970). Input conductivity data for the meteorite parent body were the present carbonaceous chondrite values up to about 800 C and the electrical conductivity of olivine above 800 C.

The results indicate that bodies up to 500 km in diameter would be heated to 1100 C (melting point of basalt) out to about 3 AU in times of one million years or less, the hypothesized length of the T-Tauri phase of the sun (Sonett et al, 1970). The distribution of asteroid types as a result of these calculations is consistent with the distribution of asteroid compositional types inferred from remote sensing (Gradie and Tedesco, 1982): carbonaceous chondrite asteroids peak at about 3 AU, more siliceous asteroids peak at about 2.4 AU.

One concern with these calculations is the use of olivine conductivity data at temperatures in excess of 800 C. We were required to use olivine conductivity at these temperatures because the conductivity of all carbonaceous chondrite samples decreased percipitously toward the olivine values. Two factors could be responsible for this decrease: oxidation of carbon in the CO_2/CO gas mixture or volatility of carbon. We are unable to separate these effects in gas mixing systems, vacuums, or inert gases because of the extremely low oxygen fugacity- less or equal to about 10^{-15} Pa- required to prevent the oxidation of carbon at 800 C. In addition, the precipation of carbon from the more reducing CO/CO_2 gas mixes required to produce this low oxygen fugacity interferes with the conductivity measurement.

The environment in the wake of the space station can be exploited to produce oxygen fugacities less than 10^{-15} Pa (Oran and Naumann, 1977). An experimental package consisting of a one square meter shield attached to a 15 cm diameter by 40 cm long furnace and tied to a conductance bridge, furnace controller, and digital voltmeter inside the space station via umbilical cable could make the required measurements. Since heating rates as low as 0.1 C/hour are required to study kinetics of the pryolysis reactions which are the cause of the high conductivity of the carbonaceous chondrites, experimental times up to 3 months will be needed.

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Oran, W.A., et al - J. Vac. Sci. Tech. 14, 1276-1977.
Sonnett, C. P., et al - Astrophys, Space Sci. 7, 446-488, 1970.